

Leach Pressing of Apples: A Method of Increasing the Yield of Full-Flavor Juice Concentrate^a

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An improvement in the manufacture of apple juice concentrate is presented. This method, "leach pressing" of the apples, gives 12 to 18 percent greater yield of concentrate per ton of apples than the conventional method of pressing. The apples are first pressed as usual. Then the cakes of pomace are broken up, cold water of approximately equal weight is added, and the mass again pressed. When this is done promptly no undesirable flavor is imparted to the concentrate made from the mixed juice. The water added is, of course, removed in evaporating the juice to make concentrate; therefore, no dilution of the final product is caused. Experimental runs were made using three different amounts of added water. For each of the three, yield figures were obtained and full-flavor high-density concentrate made, with essence returned to it. The concentrates were of as good flavor as concentrate made from the same apples using conventional single pressing. The value of the pomace as a source of pectin is not impaired. Although the costs of evaporation are obviously increased, this is more than offset by the increase in yield, with the result that the net financial return is appreciably greater. Complete commercial cost estimates of making concentrate at each of the three dilutions were made; these showed that a moderate dilution gave the best economic return.

By the conventional method of pressing apples only about 80% of the juice is extracted, leaving in the pomace one-fifth of the juice value of the apples used. Some of this residual juice can be recovered by a second pressing, and obviously considerably more if water is first mixed with the pomace. Commercially there have been two objections to this; the second juice will have an "oxidized" flavor if the pomace is long exposed to air, and the added water dilutes the juice. The United States Standards for Grades of Canned Apple Juice, issued by the Production and Marketing Administration, exclude the juice of a second pressing. This is for single strength apple juice. No U. S. Standards exist for apple juice concentrate. Careful and rapid work can avoid deterioration of flavor, and if the juice is used to make concentrate the added water is removed.

One of the processing problems then is to avoid or minimize both fermentative and oxidative alteration of the character of the second-pressed juice. In the present work the attack was by shortening the time of exposure of the pomace to air. Another possibility, not yet investigated, is the use of an inhibiting agent in the water added to the pomace.

The costs of evaporation and processing are obviously increased by adding water, but this is more than offset by the increase in yield. This paper describes pilot-plant investigations at the Eastern Regional Research Laboratory of the United States Department of Agriculture, in which excellent full-flavor concentrated apple juice was made by this method. By "full flavor" is meant a concentrate to which there has been returned essence recovered from the juice before evaporation, thus restoring the volatile constituents which would otherwise be lost in the evaporation. Experimental runs with 3 different amounts of added water were made, yields were determined, and costs of equipment and of operation were calculated, to ascertain the most economical amount of water. With this amount of water, the quantity of concentrate produced per ton of apples is 16% greater than before. If apples cost \$20.00 a ton, leach-pressing reduces the total cost of finished high-density concentrate (68.5° Brix), including all fixed charges, by nearly one cent per 6-ounce can.

It is well known that if the cakes of pomace from conventional pressing are broken up and then repressed, more juice will be pressed out. The additional amount obtained is, with good pressing, about 9% as much as the first-pressed juice (1). If the presses give inadequate pressure, the once-pressed pomace will retain an unduly large amount of juice, and the juice from the second pressing may be as much as 13% of the first pressing (6). Addition of water to pomace has been sometimes done in commercial operations where the resulting dilution of the juice can be tolerated, for instance, in making vinegar from apple juices of high sugar content, or in the manufacture of weak fermented cider such as the French "boisson de pomme" (2). In neither of these cases is it necessary to guard against the oxidized or fermented flavor that the juice will acquire if the pomace is let stand long between pressings. In fact, Warcollier (2) recommends letting the wetted pomace soak 6 to 12 hours, although fermentation, he says, starts quickly when pomace is taken out of the press. In the manufacture of fermented cider of the English type, this has been considered to improve the flavor of the final product (1), but in our case long standing of the pomace would alter the characteristic fresh apple flavor which the concentrate is designed to possess.

EXPERIMENTAL PROCEDURE

The investigations were made on pilot-plant scale. The apples were a mixture of 2 parts Jonathan, 1 part Stayman Winesap, 1 part McIntosh and 1 part Northern Spy. They were of "peeler" and "juice" grades, and had been 2 months in storage

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at 35-40° F. A conventional cider press was used. The hammer mill had serrated hammers, 22" swing diameter, 2300 RPM, and a $\frac{1}{16}$ " screen. The hydraulic ram gave 110-120 p.s.i. pressure on the cheeses; although not extremely high, this is in the range of modern practice. Maximum pressure was reached in 7 minutes, and held for 10 minutes, which gave pomace of 74-75% moisture. Preliminary studies had shown that only 0.8% more juice would be obtained by holding the pressure for 10 minutes additional, and another 0.5% in a third 10-minute period, and in any case such long pressing times are commercially undesirable. The juice was 12.5° Brix.

The cakes of pomace from the first pressing were moderately disintegrated by a machine similar to a hammer mill run at very slow speed (450 r.p.m.), but equipped with sharp knives and a screen having 1" holes. In a tank, water was then thoroughly mixed into the pomace. To determine optimum conditions, various weights of added water were used in the different experiments, ranging from 75% to 150% of the weight of the pomace from the first press, or about 16% to 32% of the weight of the apples. These amounts of water were completely absorbed by the pomace, leaving it unchanged in appearance though somewhat softer and with more tendency to compact by pressure. The moistened pomace was re-pressed in the same manner as before. This juice, when added to the first pressed juice, gave a mixed juice which was 11.3° Brix for the 75% water addition, 10.7° Brix for the 100%, and 10.0° Brix for the 150%.

TABLE 1
Extraction efficiencies of pressing

Water added, ratio to pomace	0.75	1.00	1.50
Sugar extraction, %			
First pressing.....	81.5	81.5	81.5
Second pressing (with water).....	10.8	13.3	14.5
Total.....	92.3	94.8	96.0

Table 1 shows typical yield figures calculated from the average results of the runs made at 3 different ratios of water to pomace. The "sugar extraction" figures are expressed as pounds of sugar in the juice obtained per 100 pounds of sugar in the apples. These figures are of course in direct proportion to the amount of concentrated juice that can be made from a given quantity of apples. Thus, another way of expressing the increase in yield—in the third column, for example—is to say that for every 81.5 cans of concentrate that would be obtained by the conventional single pressing, the use of this leach-pressing system would give 14.5 cans more, or an increase of nearly 18% in the total amount. Obviously the use of still greater quantities of water would give slightly higher yields; not much higher, for the yield shown is already 96% of complete extraction. As will be discussed later, the cost of processing such greater quantities of water would be an important item. Moreover, if as much as 1.75 times the weight of the pomace is used, it is not completely absorbed by the pomace, and some dripping occurs. In commercial practice this would complicate the design of the conveyors and introduce problems of sanitation.

If the apples have been ground by a hammer mill, holding the moistened pomace for a long time before pressing will not increase the yield appreciably. With an average elapsed time of 15 minutes between adding the water and starting the second pressing, the sugar will become nearly completely equalized (by mixing and diffusion) between the pomace and the added water by the time the juice starts to run out of the press. Calculations of efficiency of the extraction obtained, based on weights and analyses of the pomace for sugar and for moisture, confirm this. With the equipment used it was not possible to investigate the adequacy of shorter times.

The value of the pomace as a commercial source of pectin is not impaired by this procedure. Analytical determinations of the pectin grade of the final pomace showed it to be at least as good as the pomace from the first pressing. Furthermore, the removal of sugar from the dried pectin, a step preliminary to the extraction of pectin, should be facilitated because there is less sugar to remove.

Quality of product. A full-flavor concentrate (68.5° Brix) was made from the combined juices of the first and second pressings, and another was made from juice that had been obtained by conventional single pressing from the same blend of apples. When diluted to drinking strength (12.5° Brix) by adding 6 volumes of water, taste tests showed that the product containing the second pressed juice had the flavor of a high-grade apple juice. It was equal in quality to the single pressed product, with a slightly different flavor which some tasters preferred.

Storage tests of the above concentrates were made at 35° F. After eight months in storage, the taste tests showed the concentrate made from the combined juice of first and second pressings to be practically equal in quality to that made from conventional juice.

EQUIPMENT SUGGESTED FOR COMMERCIAL OPERATION

No detailed recommendations for equipment for commercial operation are here made. However, the following discussion will give a prospective processor an idea as to the equipment that would be required.

The equipment needed, in addition to that required for a plant to make concentrate from apples by single pressing, includes a pomace disintegrator, a cider press, a conveyor from picker to press, provision for adding water and thoroughly mixing it into the pomace, and increased capacity in all equipment converting juice into concentrate. Table 2 shows the increase in capacity required for each department, given as a percentage of that required for single pressing. This is given for 3 typical ratios of water to pomace, 0.75, 1.00 and 1.50.

TABLE 2
Increase in equipment requirements for leach pressing
(Percent of capacity for single pressing)

Water added, % on pomace	75	100	150
Cider pressing equipment.....	50	50	50
Juice-handling equipment.....	25	36	49
Evaporating equipment.....	29	42	59
Concentrate-handling equipment.....	13	16	18

Hammer mills are used on the apple presses. No tests were made on apples ground by a grater, because it was felt that a hammer mill would mash the apple tissue more completely and so enable more rapid and complete diffusion of the juice into the added water.

The pomace from the first presses should be well broken up, free from large lumps. For this purpose a suitable machine is one similar to a hammer mill but having sharp knives, equipped with a screen with 1" holes and run at 400-500 r.p.m. Water must now be added to the pomace, and the moistened pomace conveyed to the second press, being held a short time on the way. Fifteen minutes holding, including the time to load the second press, is adequate; it is possible that a shorter time may suffice. The moistened pomace is still firm in consistency, not soupy, though liable to agglomerate if squeezed; therefore, a drag conveyor (i.e. a flat trough with scrapers) is most suitable. The mixer for holding the moistened pomace over the second press can well be a trough of large diameter, with a ribbon screw. The cloths can be loaded from a chute on the bottom of this mixer. For a plant having 2 apple presses, a third one of the same size is adequate for the second pressing of the pomace from both.

The juices from first and second pressing are combined and processed to form full-flavor concentrated apple juice, either high-density (7-fold) or frozen (4-fold). The process and commercial equipment for making the 7-fold concentrate have been described by Eskew, Phillips and Redfield (3). This publication also gives estimated costs of equipment and of production. Similar information for the frozen concentrate has been published by Eskew, Phillips, Homiller, Redfield and Davis (4). Information on making frozen concentrate has also been given by Kaufman, Nimmo and Walker (5) and by Walker, Nimmo and Patterson (7).

COSTS

In order to determine the reduction in cost of producing concentrate by leach pressing, and to discover what amount of added water gives the greatest economic return, complete cost calculations have been made for each of the 3 water ratios considered. The size of plant chosen will process 42 tons of apples per day. This is considered to be an average for moderate size apple juice plants. The product is full-flavor high-density (7-fold) concentrate of 68.5° Brix, packed in 6-ounce cans.^c

TABLE 3
Cost of producing concentrate from 42 tons apples/day,
75 days/year (dollars per day)

Water added, % on pomace	None	75	100	150
Apples.....	\$ 840	\$ 840	\$ 840	\$ 840
Labor and salaries.....	577	596	598	601
Cans, supplies, power, etc.....	585	669	695	717
Maintenance and repairs.....	157	169	172	177
Interest, depreciation, taxes, etc.....	672	754	778	814
Total cost per day.....	\$2,831	\$3,048	\$3,083	\$3,149
Output: 6-oz. cans/day.....	20,400	23,070	23,720	24,030
Total cost/can, cents.....	13.88¢	13.13¢	13.00¢	13.10¢

Table 3 shows the estimated total costs of producing concentrate in the several plants, including 5% interest on investment and 10% depreciation. Such incidental items as supplies, taxes and insurance are included. The plant is assumed to operate 75 days a year, 16 hours a day. Apples are assumed to cost \$20.00 a ton. The detailed costs given in the table are expressed as dollars per day. It will be seen that a plant using single pressing would produce only 20,400 6-ounce cans of concentrate per day, whereas the leach pressing plants produce

^c Including an allowance of 13% for unforeseen contingencies, also 20% for engineering fees, the total cost of such a plant for single pressing would be \$267,000. For leach pressing, using water equal to 75% of the weight of the pomace, it would be \$301,000; for water equal to the pomace weight, \$311,000; for water 150% of the pomace weight, \$326,000. To these figures is then added 21% for working capital.

23,000 to 24,000 according to the amount of water added.

CONCLUSIONS

The last line of the table gives the final conclusions reached by applying cost calculations to the experimental results; namely, that leach pressing will reduce the cost of producing 7-fold concentrate by nine-tenths of a cent per can, and that the addition of water equal to the weight of the pomace gives the least total cost—less than the use of either more water or less water. Different assumptions than here made will, of course, shift all these figures somewhat. Higher priced apples would increase the saving, and increase the optimum amount of water addition. So also would a longer operating season, because the additional investment would have longer to “earn its keep.” But all in all, the average expectation is that, by leach pressing, the total cost per can of concentrate can be reduced by 6 or 7%, and that 16% more cans can be made from a given crop of apples. And this can be accomplished without injuring the flavor of the product.

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